

## SEQUENCE LISTING

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<120> HEPARAN SULFATE D-GLUCOSAMINYL 3-O-SULFOTRANSFERASES,  
 AND USES THEREFOR

<130> MIT-087

<140>

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<150> WO PCT/US98/22597

<151> 1998-10-23

<150> USSN 60/065,437

<151> 1997-10-31

<150> USSN 60/062,762

<151> 1997-10-24

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<170> PatentIn Ver. 2.0

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gttccagtaa tcaagaggga gccttgctgc tacttcatga tccaggcgcg tgtggcccag 300

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 Pro Lys Leu Leu Asp Lys Leu His Glu Tyr Phe His Glu Pro Asn Lys  
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 Lys Phe Phe Lys Leu Val Gly Arg Thr Phe Asp Trp His  
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Gly Val Arg Lys Gly Gly Thr Arg Ala Leu Leu Glu Met Leu Ser Leu  
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Pro Ile Glu Asp Leu Leu Met Arg Asp Gly Arg Leu Asn Leu Asp Tyr 180 185 190		
Lys Ala Leu Asn Arg Ser Leu Tyr His Ala His Met Leu Asn Trp Leu 195 200 205		
Arg Phe Phe Pro Leu Gly His Ile His Ile Val Asp Gly Asp Arg Leu 210 215 220		
Ile Arg Asp Pro Phe Pro Glu Ile Gln Lys Val Glu Arg Phe Leu Lys 225 230 235 240		
Leu Ser Pro Gln Ile Asn Ala Ser Asn Phe Tyr Phe Asn Lys Thr Lys 245 250 255		
Gly Phe Tyr Cys Leu Arg Asp Ser Gly Lys Asp Arg Cys Leu His Glu 260 265 270		
Ser Lys Gly Arg Ala His Pro Gln Val Asp Pro Lys Leu Leu Asp Lys 275 280 285		
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Leu Val Pro Ser Arg Pro Ala Glu Leu Gly Gln Gln Glu Leu Leu Arg	
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Lys Ala Gly Thr Leu Gln Asp Asp Val Arg Asp Gly Val Ala Pro Asn	
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Gly Ser Ala Gln Gln Leu Pro Gln Thr Ile Ile Ile Gly Val Arg Lys	
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Gly Gly Thr Arg Ala Leu Leu Glu Met Leu Ser Leu His Pro Asp Val	
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Ala Ala Ala Glu Asn Glu Val His Phe Phe Asp Trp Glu Glu His Tyr	
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Ser His Gly Leu Gly Trp Tyr Leu Ser Gln Met Pro Phe Ser Trp Pro	
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His Gln Leu Thr Val Glu Lys Thr Pro Ala Tyr Phe Thr Ser Pro Lys	
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Val Pro Glu Arg Val Tyr Ser Met Asn Pro Ser Ile Arg Leu Leu Leu	
130 135 140	
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Ile Leu Arg Asp Pro Ser Glu Arg Val Leu Ser Asp Tyr Thr Gln Val	
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Phe Leu Val Arg Asp Gly Arg Leu Asn Val Asp Tyr Lys Ala Leu Asn	
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Arg Ser Leu Tyr His Val His Met Gln Asn Trp Leu Arg Phe Phe Pro	
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Leu Arg His Ile His Ile Val Asp Gly Asp Arg Leu Ile Arg Asp Pro	
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Phe Pro Glu Ile Gln Lys Val Glu Arg Phe Leu Lys Leu Ser Pro Gln  
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 Ile Asn Ala Ser Asn Phe Tyr Phe Asn Lys Thr Lys Gly Phe Tyr Cys  
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Phe Tyr Asn His Met Gln Lys His Lys Pro Tyr Pro Ser Ile Glu Glu 165 170 175		
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Arg Ser Leu Tyr His Val His Met Gln Asn Trp Leu Arg Phe Phe Pro 195 200 205		
Leu Arg His Ile His Ile Val Asp Gly Asp Arg Leu Ile Arg Asp Pro 210 215 220		
Phe Pro Glu Ile Gln Lys Val Glu Arg Phe Leu Lys Leu Ser Pro Gln 225 230 235 240		
Ile Asn Ala Ser Asn Phe Tyr Phe Asn Lys Thr Lys Gly Phe Tyr Cys 245 250 255		
Leu Arg Asp Ser Gly Arg Asp Arg Cys Leu His Glu Ser Lys Gly Arg 260 265 270		
Ala His Pro Gln Val Asp Pro Lys Leu Leu Asn Lys Leu His Glu Tyr 275 280 285		
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Gly Thr Lys Arg Leu Pro Gln Ala Leu Ile Val Gly Val Lys Lys Gly			
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Gly Thr Arg Ala Val Leu Glu Phe Ile Arg Val His Pro Asp Val Arg			
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Ala Leu Gly Thr Glu Pro His Phe Phe Asp Arg Asn Tyr Gly Arg Gly			
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Leu Asp Trp Tyr Arg Ser Leu Met Pro Arg Thr Leu Glu Ser Gln Ile			
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Thr Leu Glu Lys Thr Pro Ser Tyr Phe Val Thr Gln Glu Ala Pro Arg			
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Asn Pro Val Thr Arg Ala Ile Ser Asp Tyr Thr Gln Thr Leu Ser Lys			
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Lys Pro Asp Ile Pro Thr Phe Glu Gly Leu Ser Phe Arg Asn Arg Thr			
225	230	235	



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His Phe Tyr Phe Asn Lys Thr Lys Gly Phe Pro Cys Leu Lys Lys Thr	
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Glu Ser Ser Leu Leu Pro Arg Cys Leu Gly Lys Ser Lys Gly Arg Thr	
320 325 330	
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His Val Gln Ile Asp Pro Glu Val Ile Asp Gln Leu Arg Glu Phe Tyr	
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Arg Pro Tyr Asn Ile Lys Phe Tyr Glu Thr Val Gly Gln Asp Phe Arg	
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Trp Glu	
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35 40 45

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50 55 60

Lys Leu Leu Gln Lys Ser Arg Pro Cys Asp Pro Ser Gly Pro Thr Pro  
65 70 75 80

Ser Glu Pro Ser Ala Pro Ser Ala Pro Ala Ala Val Pro Ala Pro  
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Arg Leu Ser Gly Ser Asn His Ser Gly Ser Pro Lys Leu Gly Thr Lys  
100 105 110

Arg Leu Pro Gln Ala Leu Ile Val Gly Val Lys Lys Gly Gly Thr Arg  
115 120 125

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130 135 140

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210 215 220

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Cys Val Trp Leu Tyr Met Phe Leu Tyr Ser Cys Ala Gly Ser Cys Ala	
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Pro Asp Gly Thr Pro Pro Arg Leu Pro Phe Arg Ala Pro Pro Ala Thr  
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Glu Gln Ser Pro Glu Val Pro Asp Ser Pro Ser Pro Ile Ser Ser Phe  
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Asp Gly Gln Ile Thr Met Glu Lys Thr Pro Ser Tyr Phe Val Thr Arg  
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Glu Ala Pro Ala Arg Ile Ser Ala Met Ser Lys Asp Thr Lys Leu Ile  
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Gln	Ile	Thr	Met	Glu	Lys	Thr	Pro	Ser	Tyr	Phe	Val	Thr	Asn	Glu	Ala	
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ccc	aag	cgc	att	cac	tcc	atg	gcc	aag	gac	atc	aaa	ctg	att	gtg	gtg	1704
Pro	Lys	Arg	Ile	His	Ser	Met	Ala	Lys	Asp	Ile	Lys	Leu	Ile	Val	Val	
				275					280					285		
gtg	aga	aac	ccc	gtg	acc	agg	gcc	atc	tct	gac	tac	acg	cag	aca	ctg	1752
Val	Arg	Asn	Pro	Val	Thr	Arg	Ala	Ile	Ser	Asp	Tyr	Thr	Gln	Thr	Leu	
			290					295					300			
tca	aag	aaa	ccc	gag	atc	ccc	acc	ttt	gag	gtg	ctg	gcc	ttc	aaa	aac	1800
Ser	Lys	Lys	Pro	Glu	Ile	Pro	Thr	Phe	Glu	Val	Leu	Ala	Phe	Lys	Asn	
		305					310					315				
cgg	acc	ctc	ggg	ctg	atc	gat	gct	tcc	tgg	agt	gcc	att	cga	ata	ggg	1848
Arg	Thr	Leu	Gly	Leu	Ile	Asp	Ala	Ser	Trp	Ser	Ala	Ile	Arg	Ile	Gly	
		320				325					330					
atc	tat	gcg	ctg	cat	ctg	gaa	aac	tgg	ctc	cag	tat	ttc	ccc	ctc	tcc	1896
Ile	Tyr	Ala	Leu	His	Leu	Glu	Asn	Trp	Leu	Gln	Tyr	Phe	Pro	Leu	Ser	
335					340					345					350	
cag	atc	ctc	ttt	gtc	agt	ggt	gag	cga	ctc	att	gtg	gac	ccc	gcc	ggg	1944
Gln	Ile	Leu	Phe	Val	Ser	Gly	Glu	Arg	Leu	Ile	Val	Asp	Pro	Ala	Gly	
				355					360					365		
gaa	atg	gcc	aaa	gta	cag	gat	ttt	cta	ggc	ctc	aaa	cgt	gtt	gtg	act	1992
Glu	Met	Ala	Lys	Val	Gln	Asp	Phe	Leu	Gly	Leu	Lys	Arg	Val	Val	Thr	
			370					375					380			
aag	aag	cat	ttc	tat	ttc	aac	aaa	acc	aag	ggg	ttc	cct	tgc	cta	aag	2040
Lys	Lys	His	Phe	Tyr	Phe	Asn	Lys	Thr	Lys	Gly	Phe	Pro	Cys	Leu	Lys	
		385					390					395				
aag	cca	gaa	gac	agc	agt	gcc	ccg	agg	tgc	tta	ggc	aag	agc	aaa	ggt	2088
Lys	Pro	Glu	Asp	Ser	Ser	Ala	Pro	Arg	Cys	Leu	Gly	Lys	Ser	Lys	Gly	

400

405

410

cgg act cat cct cgc att gac cca gat gtc atc cac aga ctg agg aaa 2136  
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 415 420 425 430

ttc tac aaa ccc ttc aac ttg atg ttt tac caa atg act ggt caa gat 2184  
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ttt cag tgg gaa cag gaa gag ggt gat aaa tgaggctaga gaggcagagg 2234  
 Phe Gln Trp Glu Gln Glu Glu Gly Asp Lys  
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 <212> PRT  
 <213> Homo sapiens

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 35 40 45  
 Cys Tyr Ser Leu Leu Gly Gly Ser Gly Ser Leu Gln Phe Pro Leu Ala  
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 Leu Gln Glu Ser Pro Gly Ala Ala Ala Glu Pro Pro Pro Ser Pro Pro  
 65 70 75 80  
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 85 90 95  
 Pro Pro Ala Pro Pro Pro Leu Asp Asn Ala Ser His Gly Glu Pro Pro  
 100 105 110  
 Glu Pro Pro Glu Gln Pro Ala Ala Pro Gly Thr Asp Gly Trp Gly Leu  
 115 120 125  
 Pro Ser Gly Gly Gly Gly Ala Arg Asp Ala Trp Leu Arg Thr Pro Leu  
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 145 150 155 160  
 Ala Gln Glu Ser Ser Thr Thr Asp Glu Asp Leu Ala Gly Arg Arg Ala  
 165 170 175  
 Ala Asn Gly Ser Ser Glu Arg Gly Gly Ala Val Ser Thr Pro Asp Tyr  
 180 185 190  
 Gly Glu Lys Lys Leu Pro Gln Ala Leu Ile Ile Gly Val Lys Lys Gly  
 195 200 205  
 Gly Thr Arg Ala Leu Leu Glu Ala Ile Arg Val His Pro Asp Val Arg  
 210 215 220  
 Ala Val Gly Val Glu Pro His Phe Phe Asp Arg Asn Tyr Glu Lys Gly  
 225 230 235 240

Leu Glu Trp Tyr Arg Asn Val Met Pro Lys Thr Leu Asp Gly Gln Ile  
 245 250 255  
 Thr Met Glu Lys Thr Pro Ser Tyr Phe Val Thr Asn Glu Ala Pro Lys  
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 Arg Ile His Ser Met Ala Lys Asp Ile Lys Leu Ile Val Val Val Arg  
 275 280 285  
 Asn Pro Val Thr Arg Ala Ile Ser Asp Tyr Thr Gln Thr Leu Ser Lys  
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 Lys Pro Glu Ile Pro Thr Phe Glu Val Leu Ala Phe Lys Asn Arg Thr  
 305 310 315 320  
 Leu Gly Leu Ile Asp Ala Ser Trp Ser Ala Ile Arg Ile Gly Ile Tyr  
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 Ala Leu His Leu Glu Asn Trp Leu Gln Tyr Phe Pro Leu Ser Gln Ile  
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 Leu Phe Val Ser Gly Glu Arg Leu Ile Val Asp Pro Ala Gly Glu Met  
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 Ala Lys Val Gln Asp Phe Leu Gly Leu Lys Arg Val Val Thr Lys Lys  
 370 375 380  
 His Phe Tyr Phe Asn Lys Thr Lys Gly Phe Pro Cys Leu Lys Lys Pro  
 385 390 395 400  
 Glu Asp Ser Ser Ala Pro Arg Cys Leu Gly Lys Ser Lys Gly Arg Thr  
 405 410 415  
 His Pro Arg Ile Asp Pro Asp Val Ile His Arg Leu Arg Lys Phe Tyr  
 420 425 430  
 Lys Pro Phe Asn Leu Met Phe Tyr Gln Met Thr Gly Gln Asp Phe Gln  
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 Trp Glu Gln Glu Glu Gly Asp Lys  
 450 455

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 <211> 284  
 <212> PRT  
 <213> Homo sapiens

<220>  
 <223> human NST-1 (aa 599 to 882)

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 Thr Gly Thr Thr Ala Leu Tyr Leu Phe Leu Gly Met His Pro Asp Leu  
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Ser	Ser	Asn	Tyr	Pro	Ser	Ser	Glu	Thr	Phe	Glu	Glu	Ile	Gln	Phe	Phe	35	40	45	
Asn	Gly	His	Asn	Tyr	His	Lys	Gly	Ile	Asp	Trp	Tyr	Met	Glu	Phe	Phe	50	55	60	
Pro	Ile	Pro	Ser	Asn	Thr	Thr	Ser	Asp	Phe	Tyr	Phe	Glu	Lys	Ser	Ala	65	70	75	80
Asn	Tyr	Phe	Asp	Ser	Glu	Val	Ala	Pro	Arg	Arg	Ala	Ala	Ala	Leu	Leu	85	90	95	
Pro	Lys	Ala	Lys	Val	Leu	Thr	Ile	Leu	Ile	Asn	Pro	Ala	Asp	Arg	Ala	100	105	110	
Tyr	Ser	Trp	Tyr	Gln	His	Gln	Arg	Ala	His	Asp	Asp	Pro	Val	Ala	Leu	115	120	125	
Lys	Tyr	Thr	Phe	His	Glu	Val	Ile	Thr	Ala	Gly	Ser	Asp	Ala	Ser	Ser	130	135	140	
Lys	Leu	Arg	Ala	Leu	Gln	Asn	Arg	Cys	Leu	Val	Pro	Gly	Trp	Tyr	Ala	145	150	155	160
Thr	His	Ile	Glu	Arg	Trp	Leu	Ser	Ala	Tyr	His	Ala	Asn	Gln	Ile	Leu	165	170	175	
Val	Leu	Asp	Gly	Lys	Leu	Leu	Arg	Thr	Glu	Pro	Ala	Lys	Val	Met	Asp	180	185	190	
Met	Val	Gln	Lys	Phe	Leu	Gly	Val	Thr	Asn	Thr	Ile	Asp	Tyr	His	Lys	195	200	205	
Thr	Leu	Ala	Phe	Asp	Pro	Lys	Lys	Gly	Phe	Trp	Cys	Gln	Leu	Leu	Glu	210	215	220	
Gly	Gly	Lys	Thr	Lys	Cys	Leu	Gly	Lys	Ser	Lys	Gly	Arg	Lys	Tyr	Pro	225	230	235	240
Glu	Met	Asp	Leu	Asp	Ser	Arg	Ala	Phe	Leu	Lys	Asp	Tyr	Tyr	Arg	Asp	245	250	255	
His	Asn	Ile	Glu	Leu	Ser	Lys	Leu	Leu	Tyr	Lys	Met	Gly	Gln	Thr	Leu	260	265	270	
Pro	Thr	Trp	Leu	Arg	Glu	Asp	Leu	Gln	Asn	Thr	Arg					275	280		

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<211> 286

<212> PRT

<213> Homo sapiens

<220>

<223> human NST-2 (aa 598 to 883)

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Thr	Gly	Thr	Thr	Ala	Ile	His	Phe	Phe	Leu	Ser	Leu	His	Pro	Ala	Val
			20					25					30		
Thr	Ser	Ser	Phe	Pro	Ser	Pro	Ser	Thr	Phe	Glu	Glu	Ile	Gln	Phe	Phe
		35					40					45			
Asn	Ser	Pro	Asn	Tyr	His	Lys	Gly	Ile	Asp	Trp	Tyr	Met	Asp	Phe	Phe
	50					55					60				
Pro	Val	Pro	Ser	Asn	Ala	Ser	Thr	Asp	Phe	Leu	Phe	Glu	Lys	Ser	Ala
65					70					75					80
Thr	Tyr	Phe	Asp	Ser	Glu	Val	Val	Pro	Arg	Arg	Gly	Ala	Ala	Leu	Leu
				85					90					95	
Pro	Arg	Ala	Lys	Ile	Ile	Thr	Val	Leu	Thr	Asn	Pro	Ala	Asp	Arg	Ala
			100					105					110		
Tyr	Ser	Trp	Tyr	Gln	His	Gln	Arg	Ala	His	Gly	Asp	Pro	Val	Ala	Leu
	115						120					125			
Asn	Tyr	Thr	Phe	Tyr	Gln	Val	Ile	Ser	Ala	Ser	Ser	Gln	Thr	Pro	Leu
	130					135						140			
Ala	Leu	Arg	Ser	Leu	Gln	Asn	Arg	Cys	Leu	Val	Pro	Gly	Tyr	Tyr	Ser
145					150					155					160
Thr	His	Leu	Gln	Arg	Trp	Leu	Thr	Tyr	Tyr	Pro	Ser	Gly	Gln	Leu	Leu
				165					170					175	
Ile	Val	Asp	Gly	Gln	Glu	Leu	Arg	Thr	Asn	Pro	Ala	Ala	Ser	Met	Glu
			180					185					190		
Ser	Ile	Gln	Lys	Phe	Leu	Gly	Ile	Thr	Pro	Phe	Leu	Asn	Tyr	Thr	Arg
		195					200					205			
Thr	Leu	Arg	Phe	Asp	Asp	Asp	Lys	Gly	Phe	Trp	Cys	Gln	Gly	Leu	Glu
	210					215					220				
Gly	Gly	Lys	Thr	Arg	Cys	Leu	Gly	Arg	Ser	Lys	Gly	Arg	Arg	Tyr	Pro
225					230					235					240
Asp	Met	Asp	Thr	Glu	Ser	Arg	Leu	Phe	Leu	Thr	Asp	Phe	Phe	Arg	Asn
				245					250					255	
His	Asn	Leu	Glu	Leu	Ser	Lys	Leu	Leu	Ser	Arg	Leu	Gly	Gln	Pro	Val
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<212> PRT  
<213> Caenorhabditis elegans

<220>  
<223> putative C. elegans 3-OST

<400> 15

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Ile Val Gly Val Lys Lys Ser Gly Thr Arg Ala Leu Leu Glu Phe Leu  
35 40 45

Arg Val Asn Pro Leu Ile Lys Ala Pro Gly Pro Glu Val His Phe Phe  
50 55 60

Asp Lys Asn Phe Asn Lys Gly Leu Glu Trp Tyr Arg Glu Gln Met Pro  
65 70 75 80

Glu Thr Lys Phe Gly Glu Val Thr Ile Glu Lys Ser Pro Ala Tyr Phe  
85 90 95

His Ser Lys Met Ala Pro Glu Arg Ile Lys Ser Leu Asn Pro Asn Thr  
100 105 110

Lys Ile Ile Ile Val Val Arg Asp Pro Val Thr Arg Ala Ile Ser Asp  
115 120 125

Tyr Thr Gln Ser Ser Ser Lys Arg Lys Arg Val Gly Leu Met Pro Ser  
130 135 140

Phe Glu Thr Met Ala Val Gly Asn Cys Ala Asn Trp Leu Arg Thr Asn  
145 150 155 160

Cys Thr Thr Lys Thr Arg Gly Val Asn Ala Gly Trp Gly Ala Ile Arg  
165 170 175

Ile Gly Val Tyr His Lys His Met Lys Arg Trp Leu Asp His Phe Pro  
180 185 190

Ile Glu Asn Ile His Ile Val Asp Gly Glu Lys Leu Ile Ser Asn Pro  
195 200 205

Ala Asp Glu Ile Ser Ala Thr Glu Lys Phe Leu Gly Leu Lys Pro Val  
210 215 220

Ala Lys Pro Glu Lys Phe Gly Val Asp Pro Ile Lys Lys Phe Pro Cys  
225 230 235 240

Ile Lys Asn Glu Asp Gly Lys Leu His Cys Leu Gly Lys Thr Lys Gly  
245 250 255

Arg His His Pro Asp Val Glu Pro Ser Val Leu Lys Thr Leu Arg Glu  
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Phe Tyr Gly Pro Glu Asn Lys Lys Phe Tyr Gln Met Ile Asn His Trp  
275 280 285

Phe Asp Trp  
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<210> 16  
<211> 4045  
<212> DNA  
<213> Homo sapiens

<220>  
<223> 3-OST-4 5' promoter/exon

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